Impacts of Community Forest Management on human economic well-being across Madagascar

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Abstract

Community Forest Management (CFM) devolves forest management to local communities to achieve conservation and human well-being goals. Yet the evidence for CFM's impacts is mixed and difficult to interpret because of inadequate attention to rival explanations for the observed empirical patterns. In a national-scale analysis in Madagascar that carefully considers these rival explanations, we estimate CFM impacts on household living standards, as measured by per capita consumption expenditures. The estimated impact is positive, but small and not statistically different from zero. However, we can statistically reject substantial negative impacts (which others have suggested may exist). The estimated impacts vary conditional on household education and proximity to forests: they are more positive and statistically significant for households closer to forest and with more education. To help improve CFM design, scholars and practitioners should anticipate heterogeneity in CFM impacts and work to better characterize them, theoretically and empirically.

Introduction

Community Forest Management (CFM) is one of the most widespread conservation approaches in developing countries. It can also play an important role in the climate mitigation mechanism Reducing Emissions from Deforestation and Degradation, REDD+ (Newton et al. 2015). CFM advocates suggest it can avoid the negative impacts of forest protection on the well-being of local communities (Behera 2009). However, evidence for the impact of CFM on human well-being is mixed, with studies reporting both negative and positive impacts (Bandyopadhyay & Tembo 2010; Ameha et al. 2014; Gelo & Koch 2014), and many studies having major design limitations (Bowler et al. 2012). Therefore, well-designed studies evaluating the impacts of CFM on human well-being are needed to better direct future efforts.

Quantifying the impacts of conservation interventions is challenging (Baylis et al. 2016). One challenge is that conservation interventions are rarely randomly assigned. Characteristics that influence intervention assignment may also affect outcomes and thus can confound impact estimates (Ferraro & Pattanayak 2006). In studies of CFM impacts on well-being, these confounders are rarely identified and controlled (Engel et al. 2013).

When confounders are observable, matching designs can address the non-random assignment of interventions (Ferraro & Pattanayak 2006). Matching involves selecting comparison units that are observably similar to intervention units in terms of pre-intervention confounding characteristics (Joppa & Pfaff 2011). Ideally, matching designs have outcome baseline data gathered before intervention to control for initial conditions that may confound measures of effectiveness (Ferraro & Hanauer 2014). Unfortunately, such data rarely exist in CFM impact evaluation (Bowler et al. 2012). To indirectly assess if missing baselines are a problem, Ferraro et al. (2015) propose a falsification or placebo test. In such a test, the researcher postulates a hypothesis that is true if the empirical design does not suffer from bias because of missing baselines (Ferraro & Hanauer 2014). If the hypothesis cannot be rejected, the researcher can be more confident in a design's ability to estimate impacts without bias. To our knowledge, no CFM impact studies have used a placebo test to address the missing baseline issue.

Another major challenge in conservation impact evaluation is that different groups within the same community could experience impacts differently (Milner-Gulland et al. 2014). Consideration of heterogeneous impacts on different groups can inform policy aiming to equitably distribute conservation benefits.

Madagascar is world renowned for the biodiversity of its forests. It was also one of the first nations in the southern hemisphere to put in place a legal CFM framework (Andriantsilavo et al. 2006), which aims to conserve its highly threatened forests while providing benefits to local communities (Aubert et al. 2013). Only a few case studies (Hockley & Andriamarovololona 2007; Toillier et al. 2011; Ramamonjisoa & Rabemananjara 2012) have empirically investigated the impacts of CFM on human well-being. None of these studies were at a national scale and none adequately controlled for confounding variables.

We investigate the impacts of CFM in Madagascar on household living standards, as measured by household consumption expenditures. CFM could produce positive and negative impacts on household living standards. Negative impacts could result from benefits forgone (due to restrictions on use of forest resources) or the costs of forest management (e.g. patrolling). Positive impacts could result from improved forest management, which could enhance forest productivity and ecosystem services important for livelihoods. CFM communities can also benefit from developing ecotourism or through external support (Hockley & Andriamarovololona 2007). For example, Madagascar's new protected areas, which include most CFM sites, received up to US$ 10.5 million of external support in 2011 alone (Carret 2013).

These impacts may be heterogeneous. Previous studies suggest that that more educated households capture more CFM benefits (Pollini & Lassoie 2011) and that households within or nearer forests are more politically and socio-economically disadvantaged and more negatively affected by conservation interventions (Ratsimbazafy et al. 2011). Thus we hypothesize that positive and negative effects will vary as a function of household education level and proximity to forest.

Methods

Study areas

Our study covers all of Madagascar's land area. We define CFM as natural forests, with clearly defined boundaries, managed by a local forest management group that entered into a signed management agreement with the state forest department under the 1996 or 2001 Malagasy CFM legislation. Our data report 1,019 CFM sites in 2014, covering about 15% of the nation's natural forests (Figure 1A, Table S1 for sources of data).

Unit of analysis

Our unit of analysis is the household. CFM households are defined as households within a commune that has 10% or more of its area covered by CFM; we also performed a sensitivity test using a threshold of 25%. Non-CFM households are households within a commune that has less than 1 % of its area covered by CFM. Households within urban communes, communes that have between 1% and 10% of their area covered by CFM, or communes that have less than 5% of their areas forested were excluded (Figure 1B). More detail concerning our justification for choosing the percent CFM cover of a commune to define the unit of analysis is in Text S1.

Well-being outcome variable

The outcome variable is annual household per capita consumption expenditure. Household consumption has been the core of living standard surveys in many developing countries (Beegle et al. 2012) and living standard is widely recognized as an important component of well-being (Bérenger & Verdier-Chouchane 2007). While we acknowledge that "well-being" is multi-dimensional (King et al. 2014), data on other dimensions of well-being at an appropriate scale are unavailable.

We pooled cross sectional data on household consumption from the 2010 and 2012 national household surveys undertaken by Madagascar statistical agency (INSTAT). The two surveys, carried out on different nationally representative samples, provide comparable data covering food and non-food consumption, spending on durable goods and housing from 29,380 randomly sampled households. These consumption items were aggregated following Deaton & Zaidi (2002). We adjusted for regional and temporal differences in prices and converted to US dollar using the World Bank 2005 purchasing power parity conversion factor.

We estimated the average impact of CFM on consumption for the CFM households, also known as the Average Treatment effect on the Treated (ATT). Because CFM restricts some forest use and past studies suggest that CFM has had negative impacts on human well-being in Madagascar (Hockley & Andriamarovololona 2007; Toillier et al. 2011; Ramamonjisoa & Rabemananjara 2012), we explicitly tested whether we can reject the hypothesis that CFM has caused a moderate decline in per capita consumption, which we define as a decline of a quarter standard deviation (of the outcome variable for the matched comparison units).

To allow at least three years of impact, we only evaluated CFM established before 2007 (inclusive) with the 2010 household data. For the 2012 household data, only CFM established before 2009 (inclusive) was considered. The numbers of sampled CFM and non-CFM households are shown in Table 1.

Matching and post-matching analyses

Matching pairs CFM households with non-CFM households that are similar in terms of potentially confounding characteristics at baseline. If one assumes that, after matching, the only systematic difference between CFM and non-CFM households is the presence of CFM, the difference in consumption in CFM and matched non-CFM households is an unbiased estimator of the ATT; in other words, one can assume that the expected non-CFM household consumption equals the expected counterfactual consumption in the CMF households had there been no CFM.

We executed one-to-one matching with replacement with a genetic matching algorithm (see “matching” package in R; Sekhon 2011). To adjust for remaining post-matching covariate imbalance, we performed weighted mixed-effects linear regression, with commune as random intercept, on the matched dataset. Studies show that combination of matching and regression yield more accurate estimate than either of them alone (Ferraro & Miranda 2014).

Confounding characteristics

Previous research has shown that site level characteristics, like human pressure and access (Table 2), can affect both assignment of forests to CFM (Rasolofoson et al. 2015) and household consumption (Stifel et al. 2003). Moreover, household characteristics (Table 2) not only influence where households choose to live in Madagascar (IOM 2014), but also their consumption. We thus controlled for confounding site and household characteristics in the matching analysis. Because drought in southern Madagascar and the frequent cyclones in the east are known to significantly influence household's living standards, we executed exact matching on arid and cyclonic areas (INSTAT 2011). We also performed exact matching on the year when the data were produced (2010 or 2012). We did not include community characteristics because we do not believe they strongly affect selection of sites to CFM in Madagascar, after matching on year, region, and household and site characteristics. The establishment of CFM in Madagascar has been driven by external conservation agendas rather than communities themselves (Pollini & Lassoie 2011). Many CFM sites have been designed to improve the management of newly created protected areas or to form a "green belt" that buffers the cores of these protected areas (Rasolofoson et al. 2015). Site characteristics thus have a much more powerful influence on CFM selection than community characteristics. This assumption is supported by our placebo test (next section). Nevertheless, in the Discussion and Text S2, we describe the implications of incorrectly excluding community attributes. Data sources are in Table S1.

Placebo test

Ideally, we would confirm that the matched CFM and non-CFM households had similar consumption before CFM began, thus helping to rule out pre-existing differences as explanations for post-CFM differences in consumption. We do not have pre-CFM consumption data because earlier surveys used a different sample of households. Instead, we performed a placebo test (Ferraro & Hanauer 2014) to test whether the pre-CFM observable confounding characteristics we used are sufficient to control for pre-CFM household consumption.

For the test, we used data from a 2005 INSTAT survey, which used a design similar to the 2010 and 2012 surveys, but with a different sample (Table S2). None of the sample households were in CFM sites in 2005, but some became CFM sites after 2005. We match these soon-to-be CFM (placebo) sites to sites never exposed to CFM using the same matching procedure and variables we apply to the 2010 and 2012 household data. In 2005, there is no CFM treatment yet, and thus if the matching procedure is effective, consumption expenditures in the placebo CFM and non-CFM sites should be similar, on average. If this null hypothesis cannot be rejected, the assumption that the matching procedure balances the unobservable pre-CFM consumption levels in the 2010 and 2012 samples is more plausible.

Heterogeneous impacts of CFM

To explore the heterogeneity of impacts as a function of the distance of the household location to the nearest forest edge and number of years of household head education, we followed Ferraro et al. (2011, 2015) and used a two-stage semi-parametric partial linear differencing model (PLM). The first stage consists of linearly controlling for the confounding characteristics. The second stage uses a non-parametric locally weighted scatter plot smoothing (LOESS) to estimate per capita consumption as a function of the continuous moderators: household proximity to forest or household head education. In other words, PLM allows estimating impacts across the possible values of the moderators, holding constant the other confounding characteristics (Ferraro & Hanauer 2014). We performed PLM on the matched dataset with the plm and plmplot R functions (Hanauer 2015).

Results

Before matching, the household characteristics of CFM and non-CFM households do not differ much (Tables S4, S5). In contrast, some site characteristics clearly differ: CFM communes have more forest area, a greater percentage of forest area, and less roadless and cart trackless volume. They are also less densely populated and closer to urban centers (Tables S4, S5). Matching improved covariate balance: the post-matching mean differences and mean raw eQQ differences of covariates are smaller (Tables S4, S5).

We cannot reject the null hypothesis of the placebo test, which provides indirect support for the adequacy of our empirical design. The estimated effect is 4.09% (US$ 13.60) more per capita consumption in the placebo CFM, a result that is not statistically significant (p=0.76).

After matching (Figure 2), the estimated effect of CFM on per capita consumption is positive, but small and with a confidence interval that covers US$0, regardless of whether treatment is defined as 10% of the commune covered by CFM (mean effect US$12.57; 95% CI[-$21.34, $46.48]) or 25% covered (mean effect 18.53; 95% CI[-$45.52, $82.58]). For both definitions, a quarter standard deviation decline in per capita consumption falls outside the 95% confidence interval.

Impacts of CFM are heterogeneous (Figure 3). Close to the forest edge, impacts appear positive (with a maximum estimated effect of US$50) and become negative as distance from the edge increases (with a minimum estimated effect of US$-60). Although we do not have enough data to estimate the effect precisely over the entire range, the estimates are statistically significant between one and twelve kilometers from the edge (Figure 3A).

Impacts also vary with level of education (Figure 3B). The estimated impacts increase with education (with a maximum estimated effect of US$110). For low levels of education, the estimated impacts are negative, but imprecisely estimated.

Discussion

Our results imply small mean effects of CFM on household consumption. Although one of our estimators of average impacts is too imprecise to rule out moderate positive impacts on consumption (i.e., greater than ¼ standard deviation), we can statistically reject moderate or larger negative impacts. This result is important given concerns that CFM restricts forest uses and thus may have negative impacts on household well-being (Hockley & Andriamarovololona 2007; Toillier et al. 2011; Ramamonjisoa & Rabemananjara 2012).

There are two rival explanations for this result; in other words, two factors that could mask a negative effect in our design. First, we may have omitted an important confounding variable that, even after matching on year, region and site and household characteristics, is positively correlated with exposure to CFM and with expected consumption in the absence of CFM (or negatively correlated with both; i.e., positive selection). If such a variable were to exist, CFM households, in the absence of CFM, would have had higher average consumption than their matched, non-CFM households. Estimating impacts by contrasting CFM with their matched non-CFM counterparts could thus mask a negative impact of CFM. Our understanding of CFM selection in Madagascar and the result of our placebo test are inconsistent with the presence of this form of hidden bias in our estimator, but they cannot rule it out completely.

Secondly, restrictions imposed by CFM rules could displace poor households from CFM communities to other communities (Pollini & Lassoie 2011). That displacement would increase the mean household consumption in CFM areas (and potentially lower the consumption in the sample of matched untreated households). That increase could mask a negative impact of CFM. We looked at the effect of CFM on migration and could detect no effect (see Text S3).

Estimates of average CFM impacts, however, can mask heterogeneity. While the average effect may be close to zero, some households may benefit and others may suffer. For households living closer to forests or with more education, we detected positive impacts of CFM on consumption. For households living farther from forests or with less education, we estimated negative impacts (albeit not always statistically distinguishable from zero).

Heterogeneity of impacts conditional on distance could arise because CFM attracts external assistance to CFM communities quite close to the forest edge, which cushions negative impacts of the forest use restrictions. It could also arise because CFM benefits may be higher for CFM participants and households closer to forest are more likely to participate. Heterogeneity of impacts conditional on education may arise from a variety of potential mechanisms, including elite capture of CFM benefits, which is a well-known problem with community-based interventions in developing countries (Lund and Saito-Jensen 2013), including Madagascar (Pollini & Lassoie 2011). Elite capture can cause conflicts jeopardizing effectiveness (Brown & Lassoie 2010), as well have social justice implications.

Our study has some advantages over earlier studies of CFM impacts in Madagascar, including the careful control for site and household characteristics that confound impact estimates and the consideration of potential rival explanations, such as differing baselines and migration. The national scale of the analysis is valuable for evaluating the impact of a national policy, but also has disadvantages: we are reliant on national-scale data and do not have the local insights of finer scale studies. Households living right at the forest frontier (or even within the forests) are difficult to access and may be underrepresented in our study because the INSTAT survey was not designed to look at effects of forest use restrictions. Thus, though our results are valid for the households represented in the sample, extrapolation should be done with caution. We also investigated exposure to CFM, rather than participation in CFM because we do not have information on participation of households in forest management groups. Finally, our study includes all legally-designated CFM sites; we do not have information on the quality of the implementation on the ground. Future studies will be improved by finer-scale analysis that contains information on participation of households in forest management groups and the quality of CFM implementation. To examine conditions associated with CFM effectiveness in terms of conservation and welfare outcomes jointly, future studies can combine our results with results from studies on CFM impacts on ecological outcomes (e.g. Rasolofoson et al. 2015).

Because CFM continues to be widely promoted as an approach to reducing deforestation and promoting rural development, better evidence about its impacts on human well-being is needed. Madagascar has a rich experience with CFM over nearly two decades and thus provides an opportunity to develop such evidence. To develop more generalizable evidence that can guide CFM design globally, studies in other nations will be required, as will better theories about CFM program participation (why are some communities and households participating and others are not?) and more elaborate, mechanism-based theories about how CFM can affect human welfare and which household and contextual factors moderate those impacts.

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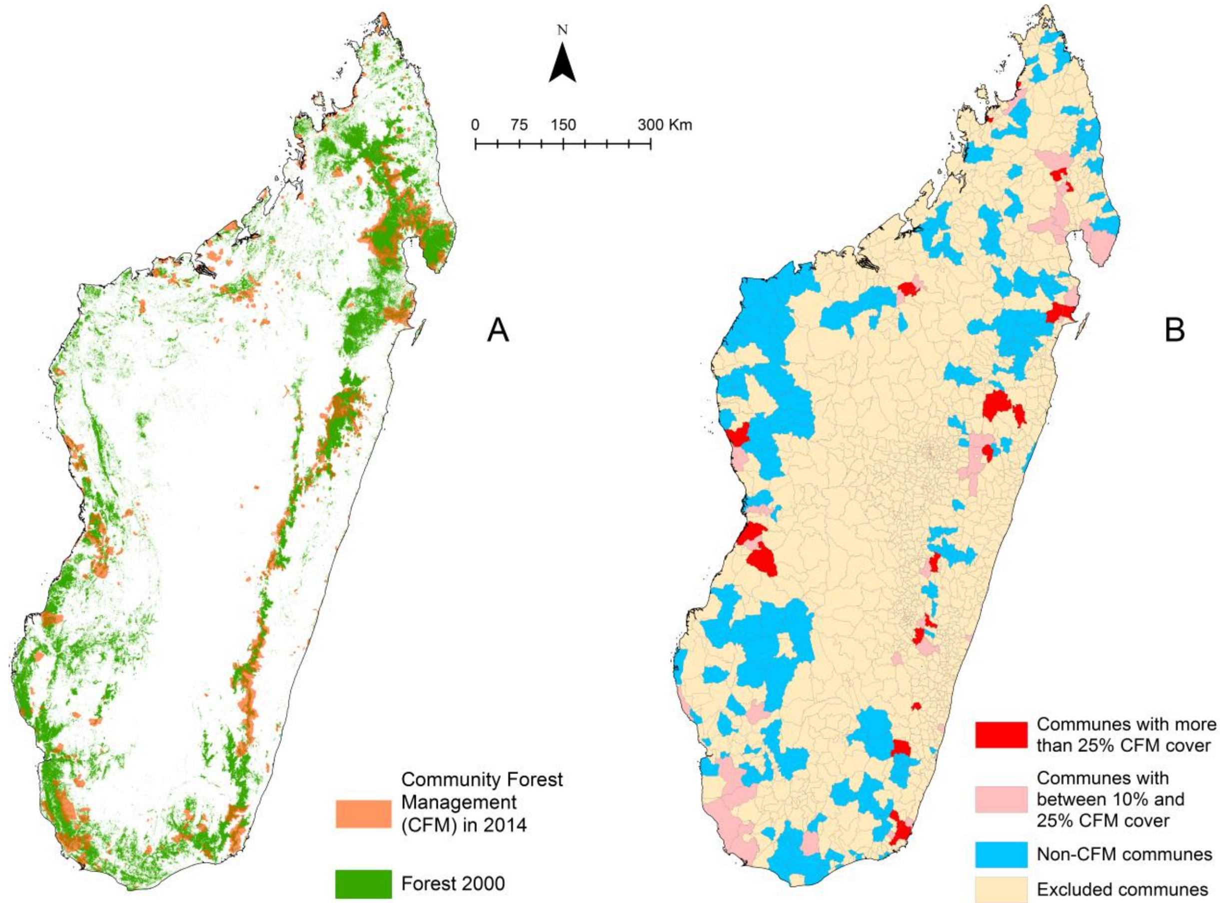

Figure 1. Study sites. A) Community Forest Management (CFM) sites in 2014; B) CFM communes, non-CFM communes, and communes excluded from the analyses (Projection: Laborde Madagascar)

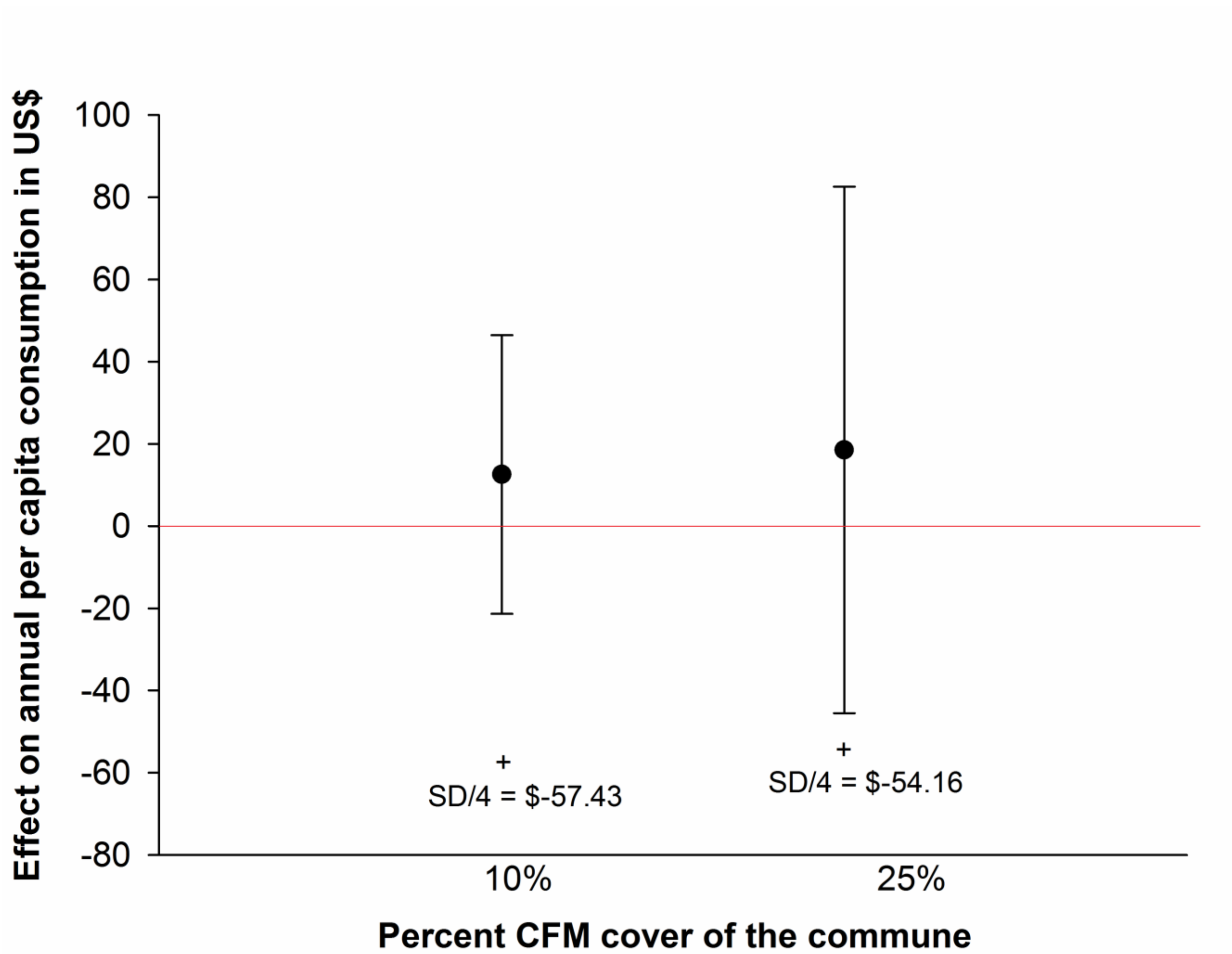

Figure 2. Impacts of Community Forest Management (CFM) on per capita consumption expenditure (+: SD/4 quarter standard deviation decline in per capita consumption expenditure, error bar: 95% confidence interval)

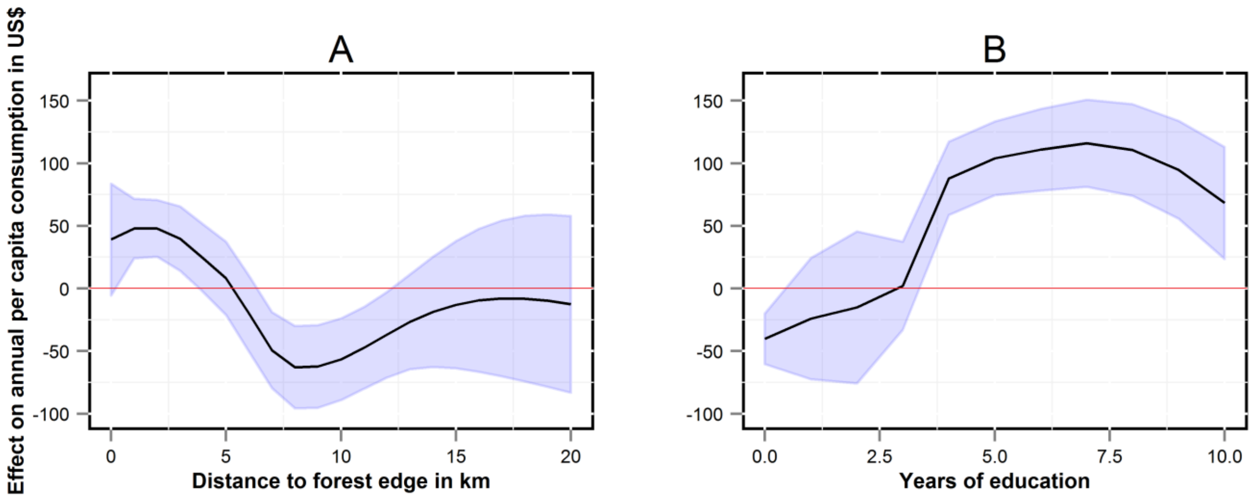

Figure 3. Heterogeneity of Community Forest Management (CFM) impacts. A) Impacts conditional on distance from the household location to the nearest forest edge, B) Impacts conditional on the number of years of education of the household head (blue band: 95% confidence interval)

Table 1. Numbers of CFM and non-CFM communes and sampled households

Dataset	Commune		Household	
	CFM	Non-CFM	CFM	Non-CFM
	Threshold 10% CFM cover of the commune			
2010	54	165	698	2,179
2012	61	164	760	1,938
Total			1,458	4,117
	Threshold 25% CFM cover of the commune			
2010	21	165	115	2,179
2012	25	164	303	1,938
Total			418	4,117

Table 2. Confounding characteristics

	Variables	Unit
Site characteristics	Slope (average, maximum)	Commune
	Elevation (average, maximum)	Commune
	Roadless volume	Commune
	Cart trackless volume	Commune
	Suitable for irrigated rice	Commune
	Area of forest land	Commune
	Proportion of forested land	Commune
	Duration of trip to the nearest urban center	Commune
	Population density	Commune
	Proportion of forest protected areas (MNP)	Commune
	Proportion of forest land	Commune
Household characteristics	Household head age	Household
	Household head without any formal education	Household
	Household head with primary education	Household
	Household with secondary education or higher	Household
	Household head gender	Household
	Single female household head	Household
	Presence of a child under 5	Household
	Presence of a disabled individual (5 years old or more)	Household